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ing of the lips and teeth, or the meeting of the tongue and palate, admit of varieties dependent on the actions of the pharynx and velum palati. The emphasis and accent given to particular syllables arise from two sources: namely, the variation in the action of the chest, and in the action of the pharynx.

This minute accommodation of action evinces not merely the perfection of the organ, but also its great subordination to the will; and in this respect the muscular apparatus of the throat admits of comparison with the delicate adjustments in the eye. Stammering arises, not from the defect in any single part, but from imperfect power of combining the requisite actions.

The author concludes by enumerating the variety of actions which must be combined before a word is uttered: namely, the compression of the thorax, the adjustment of the glottis, the elevation or depression of the larynx, and the contraction of the pharynx. He also adduces proofs of the correctness of the opinions advanced in this paper, drawn from the effects of accident and of disease occurring under his own observation; and from which he draws the following conclusions:—That the trachea gives out no sound of itself; that when the area of the passage is much diminished, the column of air has not sufficient force to move the chordæ vocales; that whatever interferes directly with the motion of the glottis reduces the voice to a whisper; that any permanent opening or defect of the velum, which prevents the distention of the pharynx and the closing of the posterior nares, renders articulation defective; that the obstruction or removal of the cells of the face deprives the voice of its body and clearness; and that nervous relaxation of the muscles of the throat is productive of great alteration in the voice. Hence the author infers the necessity of the numerous nerves which are distributed to these organs.

February 23, 1832.

HIS ROYAL HIGHNESS THE DUKE OF SUSSEX, K.G.,

President, in the Chair.

The reading of a paper, entitled, "On the Inverse Ratio which subsists between Respiration and Irritability in the Animal Kingdom; and on Hybernation," by Marshall Hall, M.D. F.R.S.E., communicated by J. G. Children, Esq. Sec. R.S. was commenced.

March 1, 1832.

HIS ROYAL HIGHNESS THE DUKE OF SUSSEX, K.G.,

President, in the Chair.

Dr. Hall's paper was resumed, and read in continuation.

March 8, 1832.

WILLIAM GEORGE MATON, M.D. Vice-President,
in the Chair.

The reading of Dr. Marshall Hall's paper, entitled "On the Inverse Ratio which subsists between Respiration and Irritability in the Animal Kingdom ; and on Hybernation," was concluded.

The object of the author, in the investigation which he has undertaken, and of which some of the results are given in the present paper, is to establish a law of the animal economy, which he expresses in the following terms : "The quantity of the respiration is inversely as the degree of the irritability." Other authors, such as Cuvier, attaching a different meaning to the term *irritability*, have stated this property, in the different classes of animals, as being directly proportional to the energy of the respiratory functions ; the purposes of which they have considered to be those of restoring to the exhausted muscular fibre its contractile power. The author of the present paper regards animal life as consisting in two essential ingredients, namely, stimulus and irritability ; atmospheric air being the principal source of the former ; the heart, where it exists, being the principal organ of the latter ; and the blood being the medium by which these are brought into contact.

For the purpose of ascertaining the quantity of respiration in any given animal, the author contrived an apparatus, to which he gives the name of the '*Pneumatometer*'. It consists of a glass jar inverted over mercury, and over the mouth of a bent tube, by which it communicates with a water-gauge of one tenth the capacity of the jar. Annexed to this apparatus, but unconnected with it, is a glass ball, containing ten cubic inches, and terminating in a tube, bent at its upper part, and of the capacity of one cubic inch, and inserted into a wider tube containing water, so as to correspond in all its pneumatic conditions with the jar and its gauge, and to point out whatever changes may have taken place in the volume of the air examined in the course of the experiment, from circumstances extraneous to it, such as variations of temperature, or of barometrical pressure. The animal, whose respiration is to be examined, is placed on a stand and covered with a jar ; and the carbonic acid produced is absorbed by pieces of calico moistened with a strong solution of caustic potass, fixed by a wire frame in the upper part of the jar. The animal, at the end of the experiment, is withdrawn under mercury, without displacing the jar ; the space it had occupied is filled with an equal volume of atmospheric air admitted into the jar ; and the volume of oxygen gas absorbed is estimated by the column of water which has risen in the gauge.

From the facts detailed by Harvey, Goodwyn and others, which establish that in asphyxia the left ventricle of the heart ceases to contract before the right ventricle, the author infers that the irritability of the latter is greater than that of the former ; and proposes

to distinguish the first as *arterio contractile*, and the latter as *veno contractile*, from the circumstance of their being stimulated respectively by arterial and by venous blood. He considers the power of bearing suspended respiration as a *measure* of irritability, which may be expressed by the length of time during which an animal can support the suspension of this function. He then shows that, conformably to these definitions, the fœtus before birth, the reptile, and the molluscous animal possess a much higher degree of irritability than the adult, or than animals belonging to the class of mammalia and birds; in which the quantity of respiration being very great, the irritability is proportionally small.

He then proceeds to consider the phenomena of hybernation; and shows that they are very similar to those of the ordinary sleep of the same animals, but differ from those of the sleep of animals which do not hybernate. In the former case the respiration is nearly, if not wholly, suspended, and the temperature greatly reduced; but the circulation continues unimpaired. He notices differences also in the habits of different hybernating animals, some of which frequently awake from their slumber during the winter, while with others the lethargy is uninterrupted. The state of hybernation should, he thinks, be carefully distinguished from the torpor induced by excessive cold; the former being a conservative, the latter a destructive process. The exclusion of atmospheric air, which is speedily fatal to the animal in its active state, is sustained with perfect impunity during hybernation, the respiration being then entirely suspended. The animal being at such times reduced to a state analogous to that of the reptile, but in a still higher degree, the irritability is much increased: the heart continues to beat without the stimulus of aerated blood, and the circulation is kept up with perfect regularity. This latter fact was ascertained by actual observation in the case of the bat, by adjusting the wing of the animal, so as to admit of its being placed in the field of a microscope without disturbing its repose. The experiments of Mangili are quoted in proof of the longer continuance of the action of the heart after decapitation, if the experiment be made in the hybernating state, than if it be made when the animal is in its ordinary state of activity.

Animals, during hybernation, are easily roused from their lethargy, and restored to sensibility and activity; and the muscles do not appear to be affected with the slightest rigidity: the respiration is immediately resumed, and the temperature rises rapidly to the natural standard. The hedgehog and the dormouse awake periodically from the sense of hunger, and the food then taken conduces to renewed lethargy. But frequent excitation from this state is productive of great exhaustion, and is often fatal to the animal. Severe cold, like other causes producing a painful impression, rouses the hybernating animal from its state of lethargy; and if continued, induces a state of torpor, which ends in death.